CLAIMS

What is claimed is:

1. Apparatus for controlling switching circuitry for generating an analog output from a digital signal, the digital signal carrying multi-bit values at a sampling rate, the digital signal including first and second digital sub-signals carrying respective least and most significant components of the multi-bit values carried by the digital signal, comprising:

pulse width modulation (PWM) circuitry operative to generate a pulse width modulated signal based on the first digital sub-signal; and

switch control circuitry under the control of the pulse width modulated signal and the second digital sub-signal and operative via the switching circuitry to produce the analog output.

2. Apparatus according to claim 1, further comprising a noise shaper operative to generate a coarsely quantized digital sub-signal from the first digital sub-signal, and wherein the PWM circuitry is operative in response to the coarsely quantized digital sub-signal.

3. Apparatus according to claim 1, wherein the digital signal is a first digital signal and the sampling rate is a first relatively high sampling rate, and further comprising an interpolator operative to perform interpolation based on a second digital signal to obtain the first digital signal, the second digital signal carrying multi-bit values at a second sampling rate lower than the first sampling rate.

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4. Apparatus according to claim 1, wherein:

the analog output is generated from a multi-level electrical signal which includes a pulse width modulated component and a multi-level component;

the switching circuitry includes a plurality of switches each operative in response to assertion of a corresponding one of switch control signals to provide one of a set of distinct levels of the multi-level electrical signal;

the PWM circuitry includes a pulse width modulation (PWM) converter operative to generate the pulse width modulated signal and a maximum-width-pulse signal, the maximum-width-pulse signal establishing the maximum permissible pulse duration in a sampling cycle for the multi-level electrical signal; and

the switch control circuitry includes a level selector operative to assert each of the switch control signals based on the pulse width modulated signal, the maximum-width-pulse signal and the second digital sub-signal.

5. Apparatus according to claim 4, wherein:

the assertion of a first one of the switch control signals by the level selector in response to a corresponding value of the second digital sub-signal establishes a base level of the multi-level electrical signal for a sampling cycle; and

during a given cycle, the level selector is further operative in response to the pulse width modulated signal to assert a second one of the switch control signals to provide a pulse level of the multi-level electrical signal, the pulse level of the multi-level electrical signal being different from the base level of the multi-level electrical signal.

6. Apparatus according to claim 5, wherein the second switch control signal is asserted during a first period of the cycle as established by the pulse width modulated signal, the first switch

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control signal is asserted during a second period which is outside the first period of the cycle and within the maximum pulse duration in the cycle as established by the maximum-width-pulse signal, and neither the first switch control signal nor the second switch control signal is asserted during a third period of the cycle constituting a remainder portion beyond the maximum permissible pulse duration.

7. Apparatus according to claim 5, wherein the lowest value of the second digital sub-signal corresponds to the lowest base level of the multi-level electrical signal which is also the lowest level of the multi-level electrical signal, and successively higher values of the second digital sub-signal correspond to successively higher base levels of the multi-level electrical signal.

8. Apparatus according to claim 4, wherein each of the levels in the set of distinct levels is a corresponding multiple of a reference level.

9. Apparatus according to claim 4, wherein the plurality of switches are arranged in a multiple H-bridge configuration and are operative to apply either (1) zero voltage level to both ends of a load connected to the switches, or (2) equal magnitudes of a positive and negative voltage level to opposite ends of the load at one time, such that current flowing through the load in one direction represents one positive voltage level, current flowing through the load in the reverse direction represents one negative voltage level, and no current flowing through the load represents a zero voltage level.

10. Apparatus according to claim 4, wherein the analog output is an acoustic analog output.

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11. Apparatus according to claim 10, wherein the acoustic analog output is an audio output.

12. Apparatus according to claim 4, wherein control of the magnitude of the analog output is obtained by controlling the magnitude of each of the set of distinct levels of the multi-level electrical signal.

13. Apparatus according to claim 4, wherein:

the multi-level electrical signal is one of a plurality of multi-level electrical signals from which the analog output is generated, each multi-level electrical signal being generated from a corresponding one of a plurality of channels;

the plurality of switches is one set of a plurality of sets of switches, each set being associated with a corresponding one of the channels, and the switch control signals are one set of a plurality of first sets of control signals, each first set of control signals being associated with a corresponding channel, each switch in the set of switches for each channel being operative in response to assertion of a corresponding one of the first set of control signals for the channel to provide one of the set of distinct levels of the multi-level electrical signal of the channel; and

the level selector is one of a plurality of level selectors each being associated with a corresponding one of the channels, the level selector of each channel being operative to assert each of the first set of control signals of the channel in response to a corresponding one of a plurality of second sets of control signals;

and further comprising an encoder operative to generate the second sets of control signals based on the second digital sub-signal.

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14. Apparatus for controlling switching circuitry for generating an analog output from a digital signal, the digital signal carrying multi-bit values at a sampling rate, the digital signal including first and second digital sub-signals carrying respective least and most significant components of the multi-bit values carried by the digital signal, the analog output being generated by additively combining a plurality of analog component outputs from a corresponding plurality of channels, each analog component output being generated from a corresponding one of a plurality of electrical signals, the switching circuitry including a plurality of switches, each switch being associated with a corresponding one of the channels, the switch for each channel being operative based on assertion of a corresponding one of switch control signals to generate a predetermined level on the electrical signal of the channel, the apparatus comprising:

pulse width modulation (PWM) circuitry operative via the switching circuitry to produce a corresponding one of a plurality of analog component outputs based on the first digital sub-signal; and

switch control circuitry operative to assert different numbers of the switch control signals based on the second digital sub-signal.

15. Apparatus according to claim 14, further comprising a noise shaper operative to generate a coarsely quantized digital sub-signal from the first digital sub-signal, and wherein the PWM circuitry is operative in response to the coarsely quantized digital sub-signal.

16. Apparatus according to claim 14, wherein the digital signal is a first digital signal and the sampling rate is a first relatively high sampling rate, and further comprising an

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interpolator operative to perform interpolation based on a second digital signal to obtain the first digital signal, the second digital signal carrying multi-bit values at a second sampling rate lower than the first sampling rate.

17. Apparatus according to claim 14, wherein the predetermined level generated on each of the electrical signals is the same.

18. Apparatus according to claim 14, wherein the switch control circuitry includes an encoder operative to assert zero switch control signals when the value of the second digital sub-signal is zero, and successively greater numbers of the switch control signals for successively higher values of the second digital sub-signal.

19. Apparatus according to claim 14, wherein:

the plurality of electrical signals include fixed-pulse-width electrical signals and a variable-pulse-width electrical signal, and the analog component outputs include fixed-pulse-width analog component outputs and a variable-pulse-width analog component output generated from the fixed-pulse-width electrical signals and a variable-pulse-width electrical signal respectively;

the analog output is further generated by additively combining the fixed-pulse-width analog component outputs with the variable-pulse-width analog component output;

the switching circuitry includes a switch operative in response to assertion of a pulse width modulated signal to generate a predetermined level on the variable-pulse-width electrical signal; and

the PWM circuitry includes a pulse width modulation (PWM) converter operative to generate the pulse width modulated signal and a maximum-width-pulse signal, the pulse width modulated

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signal being based on the first digital sub-signal, the maximum-width-pulse signal establishing the pulse duration in a sampling cycle for the fixed-pulse-width electrical signals.

20. Apparatus according to claim 14, wherein each of the plurality of switches is coupled to a different power supply.

21. Apparatus according to claim 14, wherein:

each of the electrical signals is a multi-level electrical signal generated from a corresponding channel;

each of the switches is a first switch of a corresponding set of switches in a corresponding one of the channels, and each of the switch control signals is one of a first set of control signals of the corresponding channel, each switch within each set of switches for each channel being operative in response to assertion of a corresponding one of the first set of control signals of the channel to generate one of a set of distinct levels of the multi-level electrical signal of the channel; and

the switch control circuitry further includes a plurality of level selectors each associated with a corresponding channel, each level selector being operative to assert each of the first set of control signals of the channel in response to a corresponding one of a plurality of second sets of control signals;

and further comprising an encoder operative to generate the second sets of control signals based on the second digital sub-signal.

22. Apparatus according to claim 14, wherein the digital signal is a first frequency component and each of the analog component outputs is in a first frequency band associated with the first frequency component, the analog component outputs in the first frequency band being additively combined to form a first

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frequency analog output, and the analog output is generated by additively combining the first frequency analog output in the first frequency band with a second frequency analog output in a second frequency band associated with a second frequency component, and wherein the switching circuitry, PWM circuitry, switch control signals and switch control circuitry are first switching circuitry, first PWM circuitry, first switch control signals and first switch control circuitry respectively, and further comprising:

a band-separating filter operative to generate the first and second frequency components of the digital signal;

second switching circuitry including a switch operative in response to assertion of a pulse width modulated signal to generate a predetermined level on an electrical signal from which the second frequency analog output is generated; and

second PWM circuitry operative to generate the pulse width modulated signal based on the second frequency component.

23. Apparatus according to claim 22, wherein:

the second frequency component includes third and fourth digital sub-signals carrying respective least and most significant components of the second frequency component;

the electrical signal is one of a plurality of electrical signals in the second frequency band, each electrical signal being generated from a corresponding one of a plurality of channels in the second frequency band, the second frequency analog output being generated by additively combining a plurality of analog component outputs from the plurality of channels in the second frequency band, each analog component output in the second frequency band being generated from a corresponding one of a plurality of electrical signals of the channels in the second frequency band;

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the switch in the second switching circuitry is one of a plurality of switches, each switch being associated with a corresponding one of the channels in the second frequency band, the switch for one of the channel in the second frequency band being operative in response to assertion of a pulse width modulated signal to generate a predetermined level on a corresponding one of the electrical signals, the switch for each of the other channels in the second frequency band being operative in response to assertion of a corresponding one of second switch control signals and a maximum-width-pulse signal to generate a predetermined level on the electrical signal of the corresponding channel in the second frequency band, the maximum-width-pulse signal establishing the pulse duration in a sampling cycle for the electrical signals of those other channels in the second frequency band; and

the second PWM circuitry operative to generate the pulse width modulated electrical signal and the maximum-width-pulse signal, the pulse width modulated signal being based on the third digital sub-signal; and further comprising

second switch control circuitry including an encoder operative to assert different numbers of the second switch control signals based on the fourth digital sub-signal.

24. Apparatus according to claim 22, wherein the first frequency band is a higher frequency band with more channels and the second frequency band is a lower frequency band with fewer channels.

25. Apparatus according to claim 14, wherein the analog output is an acoustic analog output.

26. Apparatus according to claim 25, wherein the acoustic analog output is an audio output.

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27. Apparatus according to claim 14, the apparatus being contained within a single enclosure.

28. Apparatus according to claim 14, wherein control of the magnitude of the analog output is obtained by controlling the magnitude of the predetermined level used by the switching circuitry of the channels.

29. Apparatus for controlling switching circuitry for generating an analog output from a digital signal, the digital signal carrying multi-bit values at a sampling rate, the digital signal including first and second digital sub-signals carrying respective least and most significant components of the multi-bit values carried by the digital signal, the analog output being generated by additively combining analog component outputs from first and second channels, the analog component output of the second channel being generated from a multi-level electrical signal, the switching circuitry including a set of switches each operative based on assertion of a corresponding one of first set of control signals for the second channel to provide one of a set of distinct levels of the multi-level electrical signal of the second channel, the apparatus comprising:

pulse width modulation (PWM) circuitry operative to generate a pulse width modulated signal and a maximum-width-pulse signal, the pulse width modulated signal being based on the first digital sub-signal, the maximum-width-pulse signal establishing the maximum permissible pulse duration in a sampling cycle for the electrical signals of the first and second channel, the pulse width modulated signal being operative via the switching circuitry to generate an electrical signal from which the analog component output of the first channel is generated;

a level selector associated with the second channel, the level selector being operative to assert each of the first set of

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control signals of the second channel in response to a second set of control signals for the second channel; and

an encoder operative to generate the second set of control signals for the second channel based on the second digital sub-signal.

30. Apparatus according to claim 29, wherein the second channel is one of a plurality of fixed-pulse-width channels;

the multi-level electrical signal is one of a plurality of multi-level electrical signals, each multi-level electrical signal being generated from a corresponding one of a plurality of fixed-pulse-width channels;

the analog output is generated by additively combining a plurality of analog component outputs from the first channel and the fixed-pulse-width channels, each analog component output of the fixed-pulse-width channels being generated from a corresponding one of the multi-level electrical signals;

the set of switches is one set of a plurality of sets of switches, each set being associated with a corresponding one of the fixed-pulse-width channels, the first set of control signals are one set of a plurality of first sets of control signals for the fixed-pulse-width channels, and the second set of control signals are one set of a plurality of second sets of control signals for the fixed-pulse-width channels, each first set of control signals for the fixed-pulse-width channels being associated with a corresponding fixed-pulse-width channel, each switch in the set of switches for each fixed-pulse-width channel being operative in response to assertion of a corresponding one of the first set of control signals for the fixed-pulse-width channel to provide one of the set of distinct levels of the multi-level electrical signal of the fixed-pulse-width channel;

the level selector is one of a plurality of level selectors each being associated with a corresponding one of the fixed-

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pulse-width channels, the level selector of each fixed-pulse-width channel being operative to assert each of the first set of control signals of the fixed-pulse-width channel in response to a corresponding one of a plurality of second sets of control signals; and

the encoder is operative to generate the second sets of control signals based on the second digital sub-signal.

31. Apparatus according to claim 29, wherein (i) the electrical signal from which the analog component output of the first channel is generated is a multi-level electrical signal, (ii) the set of switches, the first and second set of control signals, and the level selector are associated with the second channel, and (iii) the encoder is operative to generate the second sets of control signals for the first and second channel in response to the second digital sub-signal, and further comprising:

a set of switches for the first channel within the switching circuitry, each switch in the set of switches for the first channel being operative based on assertion of a corresponding one of first set of control signals for the first channel to provide one of the set of distinct levels of the multi-level electrical signal of the first channel; and

a level selector for the first channel being operative to assert each of the first set of control signals of the first channel based on the pulse width modulated signal, the maximum-width-pulse signal and the second set of control signals of the first channel.

32. Apparatus according to claim 29, wherein:

the multi-level electrical signal of the second channel is a fixed-pulse-width electrical signal, the analog component output of the second channel is a fixed-pulse-width analog component output, and the analog component output of the first

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channel is a variable-pulse-width analog component output generated from a variable-pulse-width electrical signal; and

the switching circuitry includes a set of switches for the first channel operative in response to assertion of the pulse width modulated signal to generate the variable-pulse-width electrical signal.

33. Apparatus according to claim 29, further comprising a noise shaper operative to generate a coarsely quantized digital sub-signal from the first digital sub-signal, and wherein the PWM circuitry is operative in response to the coarsely quantized digital sub-signal.

34. Apparatus according to claim 29, wherein the digital signal is a first digital signal and the sampling rate is a first relatively high sampling rate, and further comprising an interpolator operative to perform interpolation based on a second digital signal to obtain the first digital signal, the second digital signal carrying multi-bit values at a second sampling rate lower than the first sampling rate.

35. Apparatus according to claim 29, wherein the digital signal is a first frequency component and each of the analog component outputs is in a first frequency band associated with the first frequency component, the analog component outputs in the first frequency band being additively combined to form a first frequency analog output, and the analog output is generated by additively combining the first frequency analog output in the first frequency band with a second frequency analog output in a second frequency band associated with a second frequency component, the second frequency component including third and fourth digital sub-signals carrying respective least and most significant components of the second frequency component, and

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wherein the switching circuitry, PWM circuitry, level selector and encoder are first switching circuitry, first PWM circuitry, first level selector and first encoder respectively, and further comprising:

a band-separating filter operative to generate the first and second frequency components of the digital signal;

second switching circuitry operative in response to assertion of a third set of control signals to generate an electrical signal from which the second frequency analog output in the second frequency band is generated;

second pulse width modulation (PWM) circuitry operative to generate a pulse width modulated signal and a maximum-width-pulse signal, the pulse width modulated signal based on the third digital sub-signal, the maximum-width-pulse signal establishing the maximum permissible pulse duration in a sampling cycle for the electrical signal; and

second level selector being operative to assert each of the third set of control signals based on the pulse width modulated signal, the maximum-width-pulse signal and the fourth digital sub-signal.

36. Apparatus according to claim 35, wherein the electrical signal is a multi-level electrical signal of a plurality of multi-level electrical signals from which the second frequency analog output in the second frequency band is generated, each multi-level electrical signal being generated from a corresponding one of a plurality of channels in the second frequency band;

the second switching circuitry including a plurality of sets of switches, each set being associated with a corresponding one of the channels in the second frequency band, and the third set of control signals is one set of a plurality of third sets of control signals, each third set of control signals being

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associated with a corresponding channel in the second frequency band, each switch in the set of switches for each channel in the second frequency band being operative in response to assertion of a corresponding one of the third set of control signals for the channel in the second frequency band to provide one of a set of distinct levels of the multi-level electrical signal of the channel in the second frequency band;

the second level selector is one of a plurality of second level selectors each being associated with a corresponding one of the channels in the second frequency band, the second level selector associated with a first one of the channels in the second frequency band being operative to assert each of the third set of control signals of the first channel in the second frequency band based on the pulse width modulated signal, the maximum-width-pulse signal and a fourth set of control signals for the first channel in the second frequency band, each of the other second level selectors being operative to assert control signals of the third set of control signals of the corresponding channel in the second frequency band in response to a fourth set of control signals for the corresponding channel in the second frequency band and the maximum-width-pulse signal;

and further comprising a second encoder in the second frequency band operative to generate the fourth set of control signals for each channel in the second frequency band based on the fourth digital sub-signal.

37. Apparatus according to claim 35, wherein the first frequency band is a higher frequency band with more channels and the second frequency band is a lower frequency band with fewer channels.

38. Apparatus according to claim 29, wherein the analog output is an acoustic analog output.

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39. Apparatus according to claim 38, wherein the acoustic analog output is an audio output.

40. Apparatus according to claim 29, the apparatus being contained within a single enclosure.

41. Apparatus according to claim 29, wherein each of the levels in the set of distinct levels is a corresponding multiple of a reference level.

42. Apparatus according to claim 29, wherein control of the magnitude of the analog output is obtained by controlling the magnitude of each of the set of distinct levels of the multi-level electrical signal.

43. Apparatus according to claim 29, wherein the switches in each set of switches are arranged in a multiple H-bridge configuration and are operative to apply either (1) zero voltage level to both ends of a load connected to the switches, or (2) equal magnitudes of a positive and negative voltage level to opposite ends of the load at one time, such that current flowing through the load in one direction represents one positive voltage level, current flowing through the load in the reverse direction represents one negative voltage level, and no current flowing through the load represents a zero voltage level.

44. Apparatus according to claim 29, wherein each set of the plurality of sets of switches is coupled to a different power supply.

45. A digital audio system for generating an acoustic audio signal from a digital signal, the digital signal carrying multi-bit audio values at a sampling rate, the digital signal including

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first and second digital sub-signals carrying respective least and most significant components of the multi-bit audio values carried by the digital signal, the acoustic audio signal being generated from a multi-level electrical signal, the system comprising:

a loudspeaker;

a low-pass filter coupled to the loudspeaker;

switching circuitry coupled to the low-pass filter, the switching circuitry including a plurality of switches each operative in response to assertion of a corresponding one of switch control signals to provide one of a set of distinct levels of a multi-level electrical signal, the multi-level electrical signal being provided to the low-pass filter;

pulse width modulation (PWM) circuitry operative to generate a pulse width modulated signal and a maximum-width-pulse signal, the pulse width modulated signal being based on the first digital sub-signal, the maximum-width-pulse signal establishing the maximum permissible pulse duration in a sampling cycle for the multi-level electrical signal; and

switch control circuitry including a level selector operative to assert each of the switch control signals based on the pulse width modulated signal, the maximum-width-pulse signal and the second digital sub-signal.

46. A digital audio system according to claim 45, wherein the plurality of switches are arranged in a multiple H-bridge configuration and are operative to apply either (1) zero voltage level to both ends of a load connected to the switches, or (2) equal magnitudes of a positive and negative voltage level to opposite ends of the load at one time, such that current flowing through the load in one direction represents one positive voltage level, current flowing through the load in the reverse direction

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represents one negative voltage level, and no current flowing through the load represents a zero voltage level.

47. A digital audio system according to claim 45, wherein the switching circuitry is operative to select positive and negative voltages to generate the acoustic audio signal.

48. A digital audio system according to claim 45, wherein each of the levels in the set of distinct levels is a corresponding multiple of a reference level and control of the volume of the acoustic audio signal is obtained by controlling the magnitude of the reference level.

49. A digital audio system for generating an acoustic audio signal from a digital signal, the digital signal carrying multi-bit audio values at a sampling rate, the digital signal including first and second digital sub-signals carrying respective least and most significant components of the multi-bit audio values carried by the digital signal, the acoustic audio signal being generated by additively combining a plurality of acoustic audio component signals from a corresponding plurality of channels, each acoustic audio component signal being generated from a corresponding one of a plurality of pulse electrical signals which include fixed-width pulse electrical signals and a variable-width pulse electrical signal, the system comprising:

a plurality of loudspeakers each associated with a corresponding one of the channels;

a plurality of low-pass filters each coupled to a corresponding one of the loudspeakers;

switching circuitry coupled to the low-pass filters, the switching circuitry including a plurality of switches, each switch being associated with a corresponding one of the channels, the switch for one of the channels being operative on assertion

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of a pulse width modulated signal to generate the variable-width pulse electrical signal, the switch for each of the other channels being operative on assertion of a corresponding one of switch control signals and a maximum-width-pulse signal to generate the corresponding fixed-width pulse electrical signal, the maximum-width-pulse signal establishing the pulse duration in a sampling cycle for the fixed-width pulse electrical signals, each pulse electrical signal being provided to the corresponding low-pass filter;

pulse width modulation (PWM) circuitry operative to generate the pulse width modulated signal and the maximum-width-pulse signal, the pulse width modulated signal being based on the first digital sub-signal; and

an encoder operative to assert different numbers of the switch control signals based on the second digital sub-signal.

50. A digital audio system according to claim 49, wherein the digital signal is a first frequency component and each of the acoustic audio component signals is in a first frequency band associated with the first frequency component, the acoustic audio component signals in the first frequency band being additively combined to form a first frequency acoustic audio signal, and the acoustic audio signal is generated by additively combining the first frequency acoustic audio signal in the first frequency band with a second frequency acoustic audio signal in a second frequency band associated with a second frequency component, and wherein the channels, plurality of loudspeakers, plurality of low-pass filters, switching circuitry and PWM circuitry are first channels, a plurality of first loudspeakers, a plurality of first low-pass filters, first switching circuitry and first PWM circuitry respectively, and further comprising:

a second loudspeaker associated with the second frequency band;

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a second low-pass filter coupled to the second loudspeaker;

a band-separating filter operative to generate the first and second frequency components of the digital signal;

second switching circuitry coupled to the second low-pass filter, the second switching circuitry being operative in response to assertion of a pulse width modulated signal to generate a pulse electrical signal from which the second frequency acoustic audio signal in the second frequency band is generated; and

second pulse width modulation (PWM) circuitry operative to generate the pulse width modulated signal based on the second frequency component.

51. A digital audio system according to claim 50, wherein:

the second frequency component includes third and fourth digital sub-signals carrying respective least and most significant components of the second frequency component;

the pulse electrical signal is one of a plurality of pulse electrical signals in the second frequency band, each pulse electrical signal being generated from a corresponding one of a plurality of channels in the second frequency band, the second frequency acoustic audio signal being generated by additively combining a plurality of acoustic audio component signals from the plurality of channels in the second frequency band, each acoustic audio component signal in the second frequency band being generated from a corresponding one of a plurality of pulse electrical signals which include fixed-width pulse electrical signals and a variable-width pulse electrical signal in the second frequency band;

the switch in the second switching circuitry is one of a plurality of switches, each switch being associated with a corresponding one of the channels in the second frequency band, the switch for one of the channel in the second frequency band

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being operative in response to assertion of a pulse width modulated signal to generate the variable-width pulse electrical signal, the switch for each of the other channels in the second frequency band being operative in response to assertion of a corresponding one of second switch control signals and a maximum-width-pulse signal to generate the fixed-width pulse electrical signal for the corresponding channel in the second frequency band, the maximum-width-pulse signal establishing the pulse duration in a sampling cycle for the fixed-width pulse electrical signals in the second frequency band; and

the second PWM circuitry operative to generate the pulse width modulated electrical signal and the maximum-width-pulse signal, the pulse width modulated signal being based on the third digital sub-signal; and further comprising

second switch control circuitry including an encoder operative to assert different numbers of the second switch control signals based on the fourth digital sub-signal.

52. A digital audio system according to claim 50, wherein the first frequency band is a higher frequency band with more channels and the second frequency band is a lower frequency band with fewer channels.

53. A digital audio system according to claim 49, wherein each of the plurality of switches is coupled to a different power supply.

54. A digital audio system according to claim 49, the apparatus being contained within a single enclosure.

55. A digital audio system according to claim 49, wherein control of the volume of the acoustic audio signal is obtained by controlling the magnitude of a reference level used by the

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switching circuitry to establish the level of the pulse electrical signals.

56. A digital audio system for generating an acoustic audio signal from a digital signal, the digital signal carrying multi-bit audio values at a sampling rate, the digital signal including first and second digital sub-signals carrying respective least and most significant components of the multi-bit audio values carried by the digital signal, the acoustic audio signal being generated by additively combining acoustic audio component signals from first and second channels, the acoustic audio component signal of the second channel being generated from a multi-level electrical signal, the system comprising:

a plurality of loudspeakers each associated with a corresponding one of the channels;

a plurality of low-pass filters each coupled to a corresponding one of the loudspeakers;

switching circuitry including a set of switches each operative based on assertion of a corresponding one of first set of control signals to provide one of a set of distinct levels of the multi-level electrical signal of the second channel;

pulse width modulation (PWM) circuitry operative to generate a pulse width modulated signal and a maximum-width-pulse signal, the pulse width modulated signal being based on the first digital sub-signal, the maximum-width-pulse signal establishing the maximum permissible pulse duration in a sampling cycle for the electrical signals of the first and second channel, the pulse width modulated signal being operative via the switching circuitry to generate an electrical signal from which the acoustic audio component signal of the first channel is generated; and

a level selector associated with the second channel, the level selector being operative to assert each of the first set of

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control signals in response to a second set of control signals; and

an encoder operative to generate the second set of control signals based on the second digital sub-signal.

57. A digital audio system according to claim 56, wherein the second channel is one of a plurality of fixed-pulse-width channels;

the multi-level electrical signal is one of a plurality of multi-level electrical signals, each multi-level electrical signal being generated from a corresponding one of a plurality of fixed-pulse-width channels;

the acoustic audio signal is generated by additively combining a plurality of acoustic audio component signals from the first channel and the fixed-pulse-width channels, each acoustic audio component signal of the fixed-pulse-width channels being generated from a corresponding one of the multi-level electrical signals;

the set of switches is one set of a plurality of sets of switches, each set being associated with a corresponding one of the fixed-pulse-width channels, the first set of control signals are one set of a plurality of first sets of control signals for the fixed-pulse-width channels, and the second set of control signals are one set of a plurality of second sets of control signals for the fixed-pulse-width channels, each first set of control signals for the fixed-pulse-width channels being associated with a corresponding fixed-pulse-width channel, each switch in the set of switches for each fixed-pulse-width channel being operative in response to assertion of a corresponding one of the first set of control signals for the fixed-pulse-width channel to provide one of the set of distinct levels of the multi-level electrical signal of the fixed-pulse-width channel;

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the level selector is one of a plurality of level selectors each being associated with a corresponding one of the fixed-pulse-width channels, the level selector of each fixed-pulse-width channel being operative to assert each of the first set of control signals of the fixed-pulse-width channel in response to a corresponding one of a plurality of second sets of control signals; and

the encoder is operative to generate the second sets of control signals based on the second digital sub-signal.

58. A digital audio system according to claim 56, wherein (i) the electrical signal from which the acoustic audio component signal of the first channel is generated is a multi-level electrical signal, (ii) the set of switches, the first and second set of control signals, and the level selector are associated with the second channel, and (iii) the encoder is operative to generate the second sets of control signals for the first and second channel in response to the second digital sub-signal, and further comprising:

a set of switches for the first channel within the switching circuitry, each switch in the set of switches for the first channel being operative based on assertion of a corresponding one of first set of control signals for the first channel to provide one of the set of distinct levels of the multi-level electrical signal of the first channel; and

a level selector for the first channel being operative to assert each of the first set of control signals of the first channel based on the pulse width modulated signal, the maximum-width-pulse signal and the second set of control signals of the first channel.

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59. A digital audio system according to claim 56, wherein:

the multi-level electrical signal of the second channel is a fixed-pulse-width electrical signal, the acoustic audio component signal of the second channel is a fixed-pulse-width acoustic audio component signal, and the acoustic audio component signal of the first channel is a variable-pulse-width acoustic audio component signal generated from a variable-pulse-width electrical signal; and

the switching circuitry includes a set of switches for the first channel operative in response to assertion of the pulse width modulated signal to generate the variable-pulse-width electrical signal.

60. A digital audio system according to claim 56, wherein the digital signal is a first frequency component and each of the acoustic audio component signals is in a first frequency band associated with the first frequency component, the acoustic audio component signals in the first frequency band being additively combined to form a first frequency acoustic audio signal, and the acoustic audio signal is generated by additively combining the first frequency acoustic audio signal in the first frequency band with a second frequency acoustic audio signal in a second frequency band associated with a second frequency component, the second frequency component including third and fourth digital sub-signals carrying respective least and most significant components of the second frequency component, and wherein the switching circuitry, PWM circuitry, level selector and encoder are first switching circuitry, first PWM circuitry, first level selector and first encoder respectively, and further comprising:

a band-separating filter operative to generate the first and second frequency components of the digital signal;

second switching circuitry operative in response to assertion of a third set of control signals to generate an

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electrical signal from which the second frequency acoustic audio signal in the second frequency band is generated;

second PWM circuitry operative to generate a pulse width modulated signal and a maximum-width-pulse signal, the pulse width modulated signal being based on the third digital sub-signal, the maximum-width-pulse signal establishing the maximum permissible pulse duration in a sampling cycle for the electrical signal; and

second level selector being operative to assert each of the third set of control signals based on the pulse width modulated signal, the maximum-width-pulse signal and the fourth digital sub-signal.

61. A digital audio system according to claim 60, wherein the electrical signal is a multi-level electrical signal of a plurality of multi-level electrical signals from which the second frequency acoustic audio signal in the second frequency band is generated, each multi-level electrical signal being generated from a corresponding one of a plurality of channels in the second frequency band;

the second switching circuitry including a plurality of sets of switches, each set being associated with a corresponding one of the channels in the second frequency band, and the third set of control signals is one set of a plurality of third sets of control signals, each third set of control signals being associated with a corresponding channel in the second frequency band, each switch in the set of switches for each channel in the second frequency band being operative in response to assertion of a corresponding one of the third set of control signals for the channel in the second frequency band to provide one of a set of distinct levels of the multi-level electrical signal of the channel in the second frequency band;

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the second level selector is one of a plurality of second level selectors each being associated with a corresponding one of the channels in the second frequency band, the second level selector associated with a first one of the channels in the second frequency band being operative to assert each of the third set of control signals for the first channel in the second frequency band based on the pulse width modulated signal, the maximum-width-pulse signal and a fourth set of control signals for the first channel in the second frequency band, each of the other second level selectors being operative to assert control signals of the third set of control signals of the corresponding channel in the second frequency band in response to a fourth set of control signals for the corresponding channel in the second frequency band and the maximum-width-pulse signal;

and further comprising a second encoder in the second frequency band operative to generate the fourth set of control signals for each channel in the second frequency band based on the fourth digital sub-signal.

62. A digital audio system according to claim 60, wherein the first frequency band is a higher frequency band with more channels and the second frequency band is a lower frequency band with fewer channels.

63. A digital audio system according to claim 56, wherein each set of the plurality of sets of switches is coupled to a different power supply.

64. A digital audio system according to claim 56, the apparatus being contained within a single enclosure.

65. A digital audio system according to claim 56, wherein the switches in each set of switches are arranged in a multiple H-

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bridge configuration and are operative to apply either (1) zero voltage level to both ends of a load connected to the switches, or (2) equal magnitudes of a positive and negative voltage level to opposite ends of the load at one time, such that current flowing through the load in one direction represents one positive voltage level, current flowing through the load in the reverse direction represents one negative voltage level, and no current flowing through the load represents a zero voltage level.

66. A digital audio system according to claim 56, wherein the switching circuitry is operative to select positive and negative voltages to generate the acoustic audio signal.

67. A digital audio system according to claim 56, wherein each of the levels in the set of distinct levels is a corresponding multiple of a reference level and control of the volume of the acoustic audio signal is obtained by controlling the magnitude of the reference level.

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